Isoscaling and the symmetry energy in the central heavy ion collisions at intermediate energy

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In heavy reactions at intermediate energies the isoscaling relation , which is give below,

$$R_{21}(N,Z) = \frac{Y_2(N,Z)}{Y_1(N,Z)} = C\exp(\alpha N + \beta Z) \qquad (1)$$

has been generally observed [1,2]. Here $Y_i(N,Z)$ are the fragment yield for systems i=1,2 with different neutron and proton composition. α, β are isoscaling parameters. As discussed in refs. [3-5], the isoscaling parameters and the symmetry energy coefficient are closely related. For a multifragmentation regime, as pointed out in Ref. [6], this relation is given by:

$$\alpha(Z) = 4a_{sym}\Delta\left(Z/\overline{A}\right)^2 / T \qquad (2)$$

where a_{sym} is the symmetry energy coefficient, T is the temperature of the source and $\Delta(Z/\bar{A})^2 = \Delta(Z/\bar{A})_1^2 - \Delta(Z/\bar{A})_2^2$ represents the difference in that quantity of $(Z/\bar{A})$ for the two systems and $\bar{A}$ is the average mass number of isotopes for a given Z.

Experiments were performed, using ^{64}Zn, ^{70}Zn and ^{64}Ni beams at 40 AMeV incident on ^{58}Ni, ^{64}Ni, ^{112}Sn, ^{124}Sn, ^{197}Au and ^{232}Th targets. Details of the analysis are given in Ref. [7]. Isoscaling parameters, α(Z) and β(N), have been evaluated for all possible combinations between two reactions. The extracted isoscaling parameters are plotted as a function of $\Delta(Z/\bar{A})^2$ in Fig. 1 for Z=6 and Z=12. The

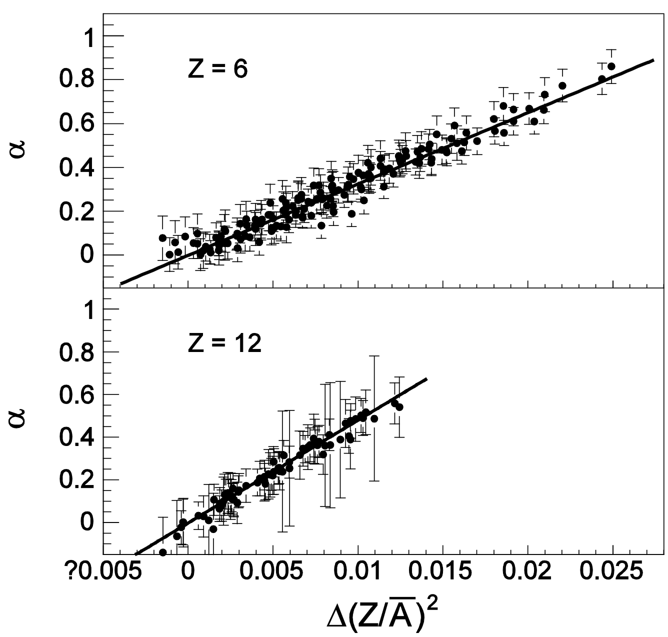

FIG. 1. α(Z) values as a function of $\Delta(Z/\bar{A})^2$ for Z=6 (upper) and Z=12 (lower).

correlations have been fit by a linear function for each Z and the slope values, which correspond to the value 4 a_{sym}/T in Eq. (2), have been extracted.

In Fig. 2, the extracted values of a_{sym}/T are plotted as a function of Z and shown by solid dots. In order to elucidate the experimentally extracted ratio, a_{sym}/T, dynamical model simulations have been made, using an Antisymmetrized Molecular Dynamics (AMD) model [8-10] and a statistical decay code, Gemini [11]. The systems examined are ^{64}Ni + ^{64}Ni, ^{64}Ni + ^{124}Sn, ^{64}Zn + ^{58}Ni, and ^{64}Zn + ^{112}Sn at 40 AMeV. All calculations have been performed in a newly installed computer cluster in the Cyclotron Institute [12]. The calculated values of a_{sym}/T are shown by open circles in Fig.2. The calculated values are typically one to two units higher than the experimental values (dots) but the trends are essentially the same. This is also consistent with the values extracted from ζ(Z) by an independent analysis described in Ref.[7].

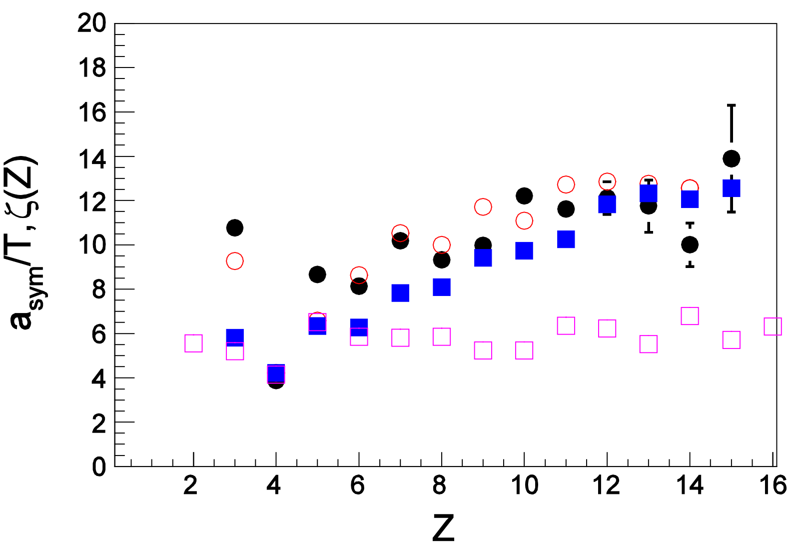

FIG. 2. Experimental a_{sym}/T values extracted from Eq. (2) are shown by dots as a function of Z. Open circles show calculated values, extracted in the same way, from the fragments yields in AMD-Gemini calculations, and open squares indicated results from the primary fragments of the AMD simulation with. The experimental results from ζ (Z) in ref.[7] are shown by the solid squares.

On the other hand the a_{sym}/T values extracted from the primary fragments of AMD show a rather flat distribution, as shown by the open squares in the figure, suggesting that the experimentally observed strong Z dependence of a_{sym}/T originates from the secondary decay process of the excited fragments after their formation.

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